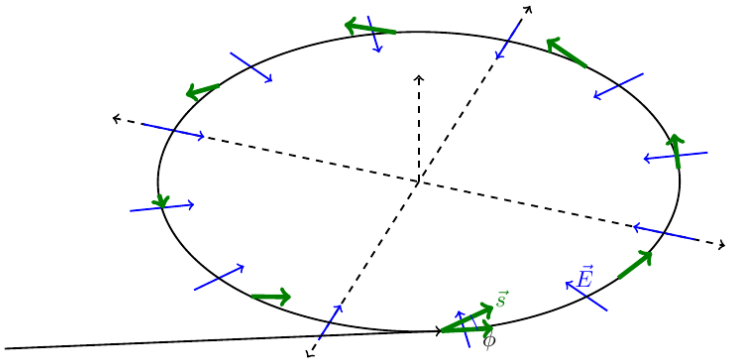
JÜLICH
FORSCHUNGSZENTRUM

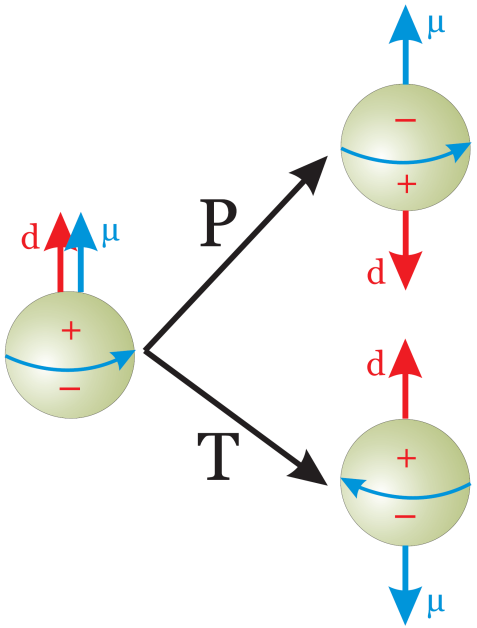
FPGA-Based Upgrade of the Read-Out Electronics for the Low Energy Polarimeter at COSY/Jülich

15.9.2015 | Nils Hempelmann |

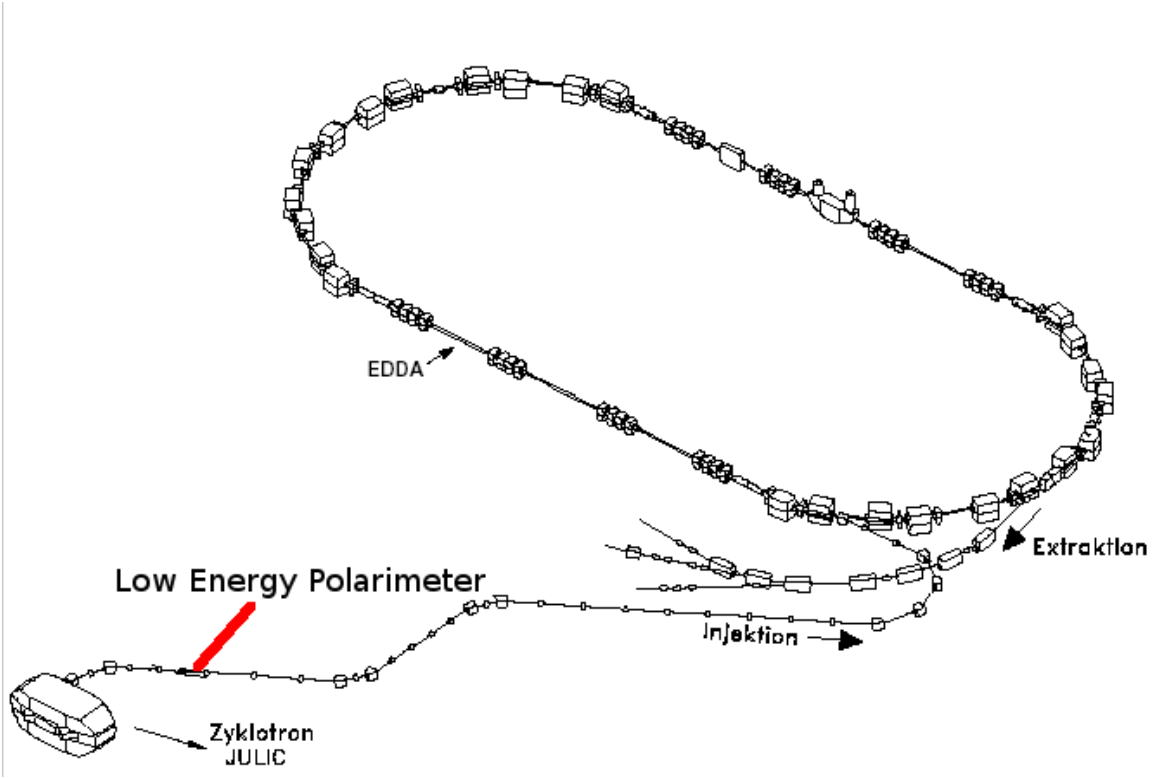
Motivation

- Nonzero electric dipole moment (EDM) violates CP-symmetry
- EDM of charged hadrons could be measured at storage rings
- Small signal, susceptible to systematic errors
- Low Energy Polarimeter at COSY measures polarization before accelerator ring





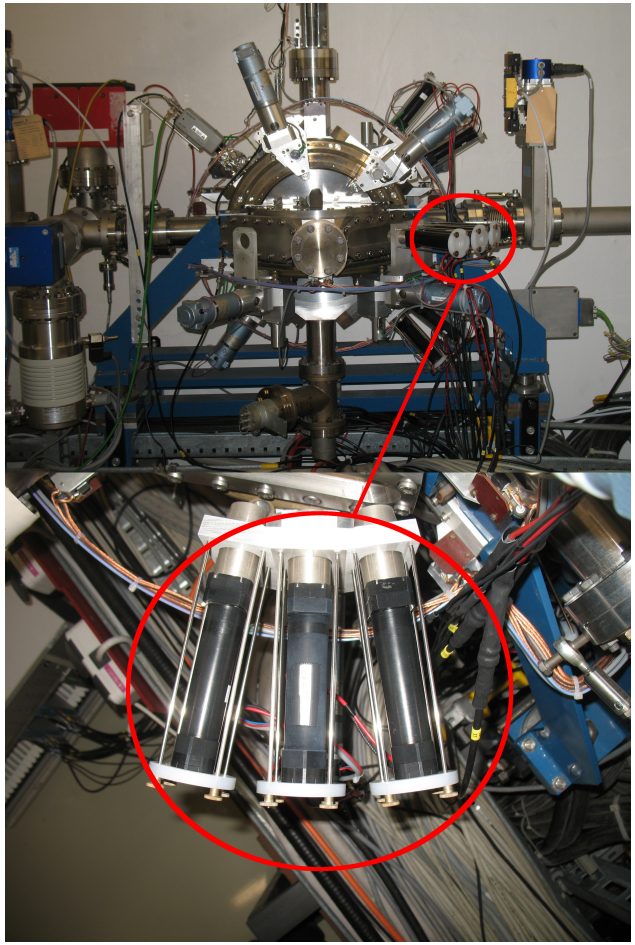
Cooler Synchrotron



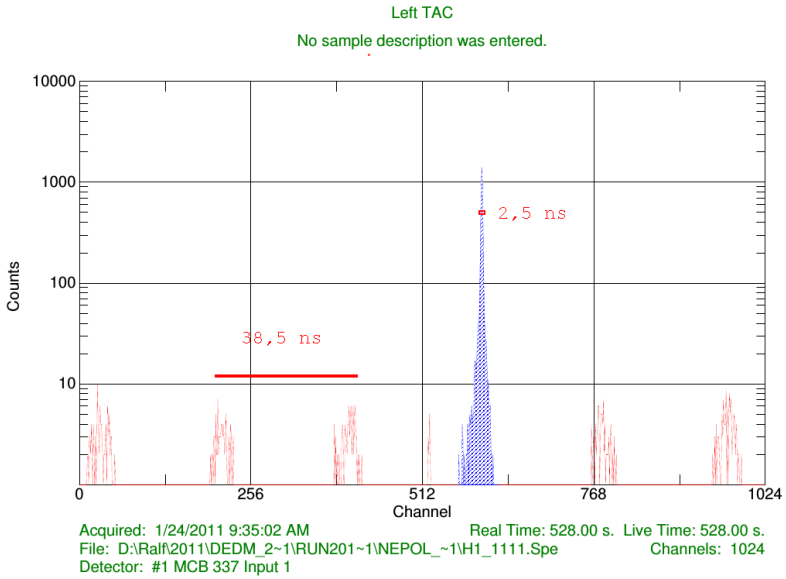
- Polarimeter located in injection beam line
- Deuterons at 75 MeV, protons at 45 MeV

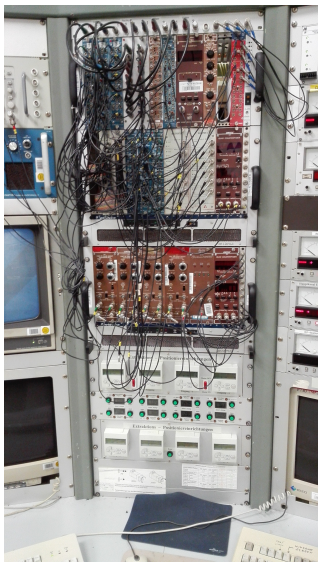
Low Energy Polarimeter

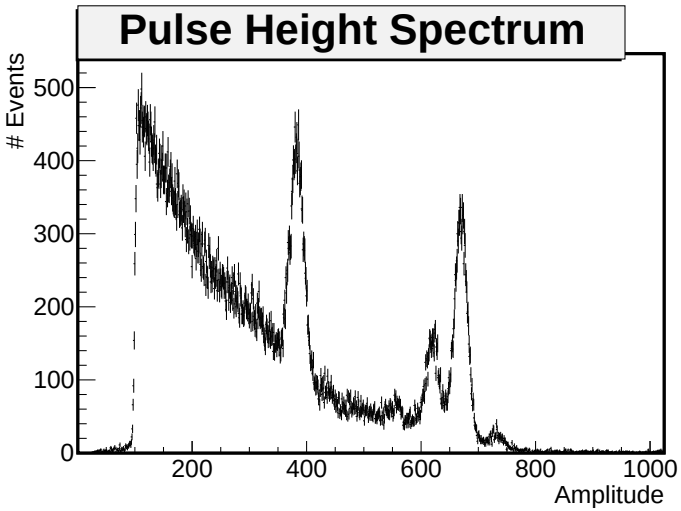
- Selectable central target: Carbon, CH_2
- 8 flanges to attach detectors
- Detectors in groups of three
- Plastic scintillators + PMTs



Old Event Selection





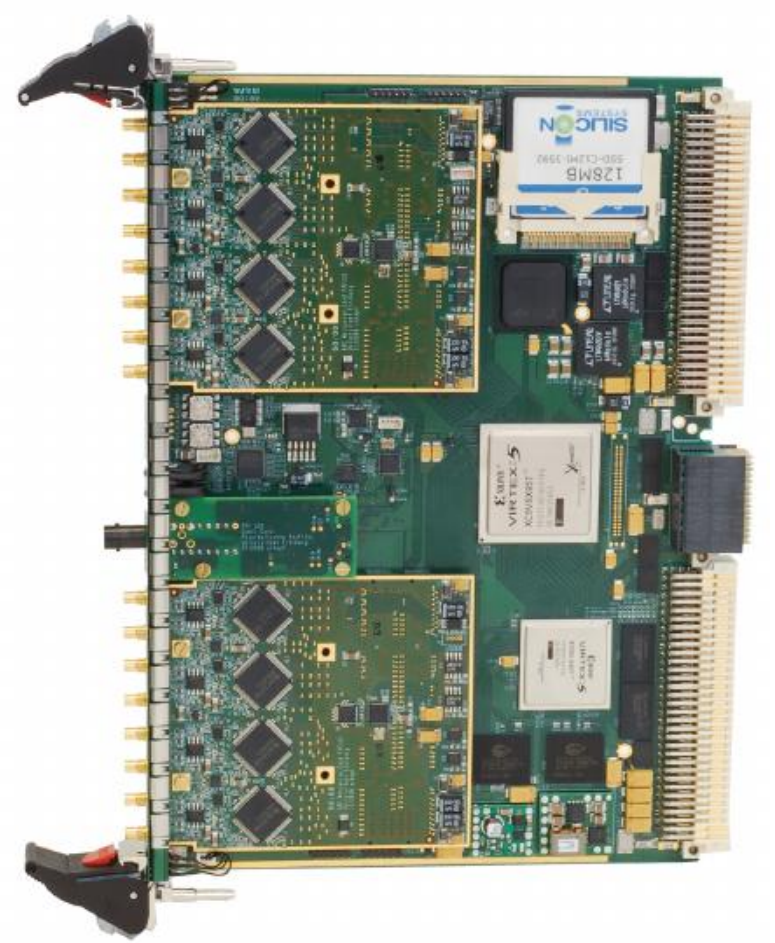


- Measure ejectile recoil coincidence
- Smaller peaks from cyclotron frequency

- Pulse height spectrum
- Proton peak, two carbon peaks
- Scintillator resolution $\approx 5\,\%$

New Electronics

- GANDALF module, Developed at University of Freiburg
- 8 ADC channels
- FPGA for readout, sampling rate 1 GHz
- USB for readout 20 MB s^{-1}
- Aim: online polarization measurement, rate $\approx$ 1 MHz



Firmware

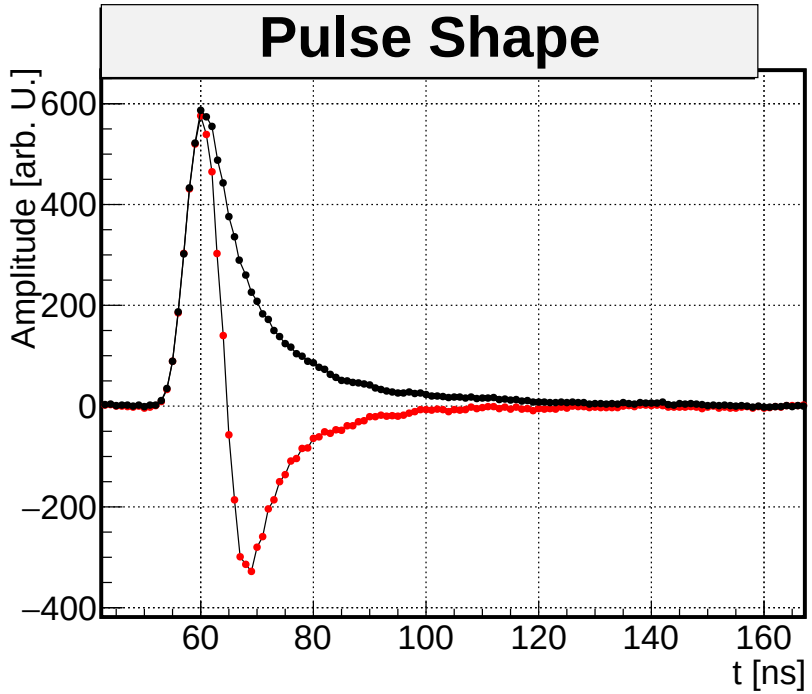
I Constant fraction discriminator
- Measures time and amplitude of each pulse
- New: Measure time of flight using cyclotron HF-signal as reference

II Counters
- Count number of events in right amplitude and time range

III Transfer to computer
- Counts of signal events
- Full event information for a fraction of events

Constant Fraction Discriminator

- Algorithm uses delay and inversion
- 1 GHz sampling rate
- Time resolution $\approx$ 50 ps
- Particle identification over amplitude and time

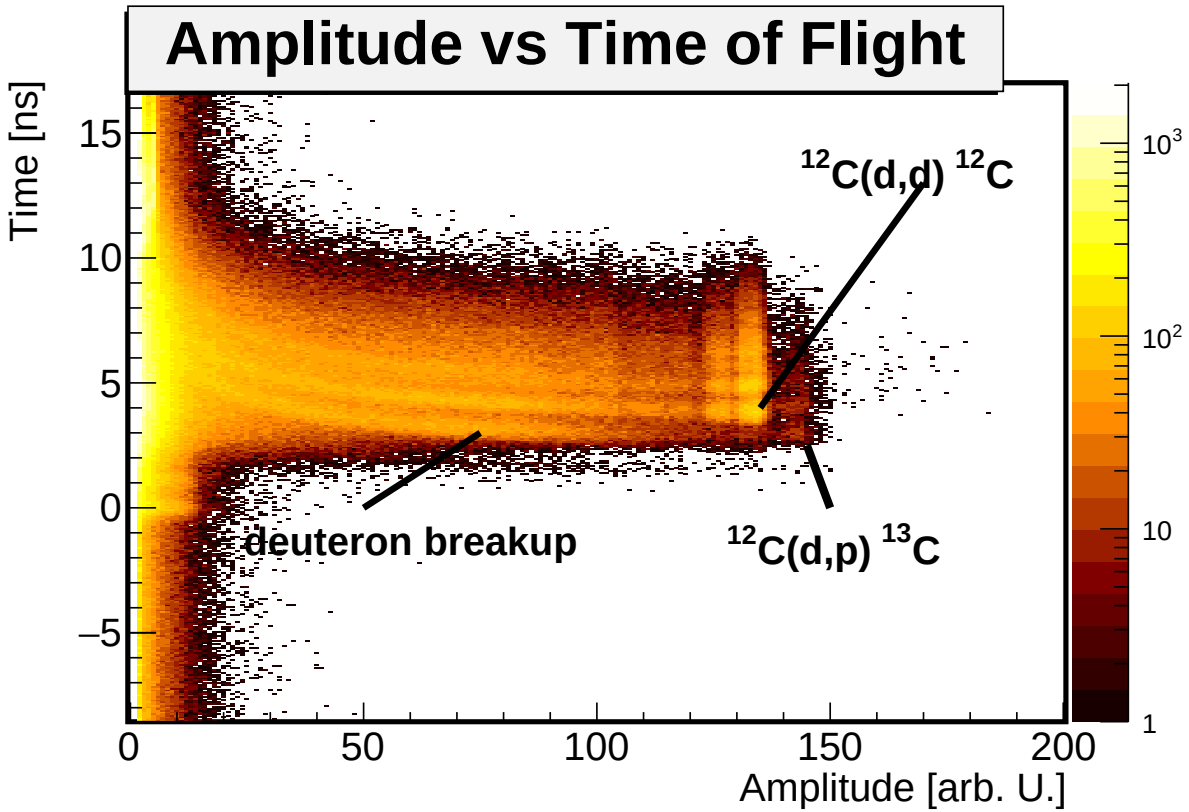


Measurements in Summer 2015 Beamtime

- Experiments with polarized 75 MeV deuterons
  - Time and amplitude spectra
  - Polarization over time
  - Asymmetry as a function of amplitude and time
- Unpolarized protons

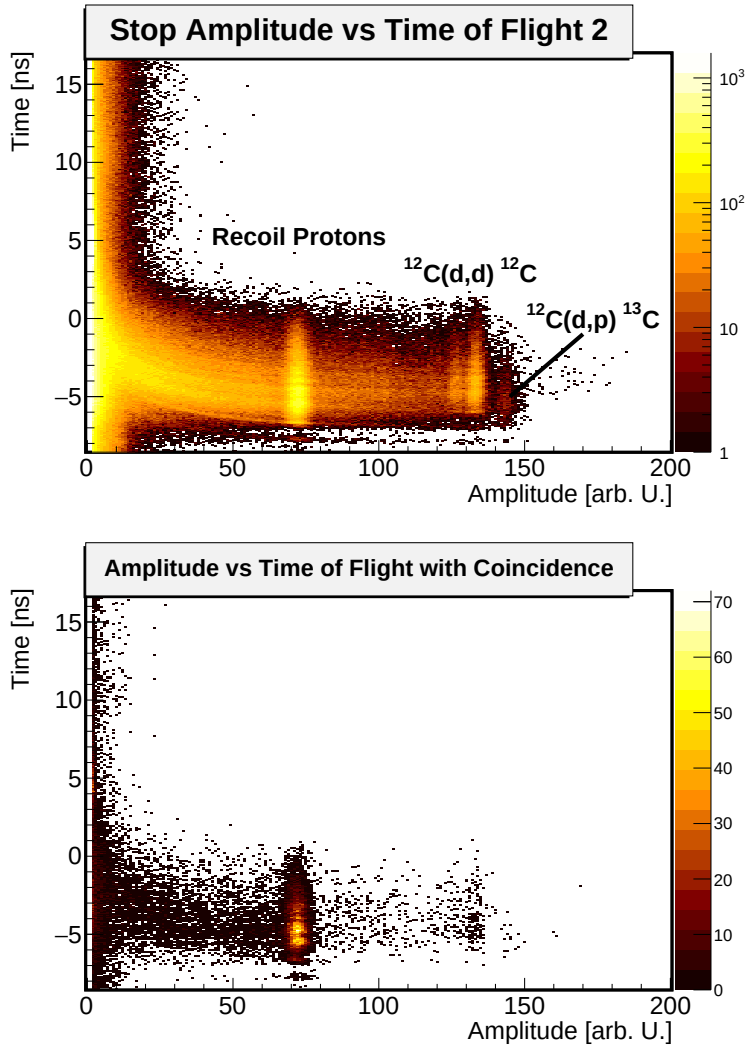
Deuteron Carbon Scattering

- Deuterons scattered off carbon target, $\theta = 40°$
- Broad multimodal distribution in time, changed during measurement

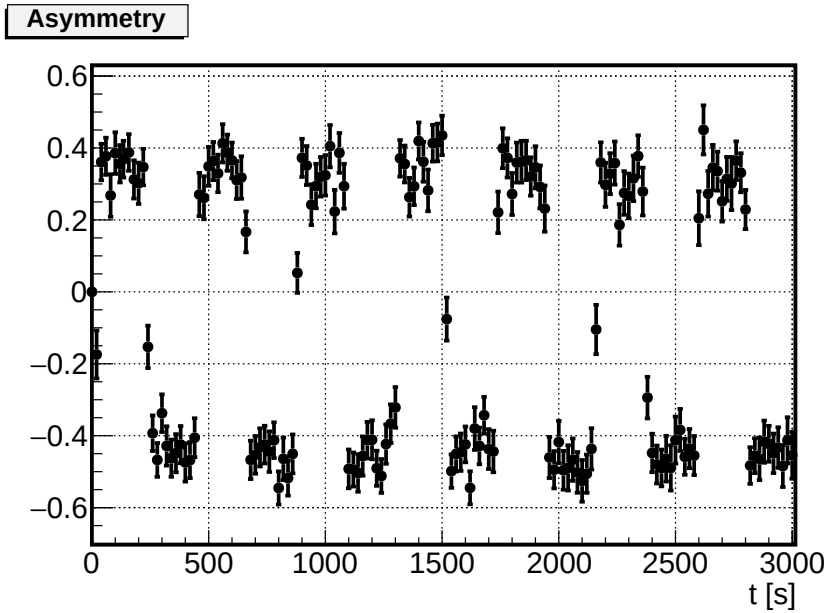


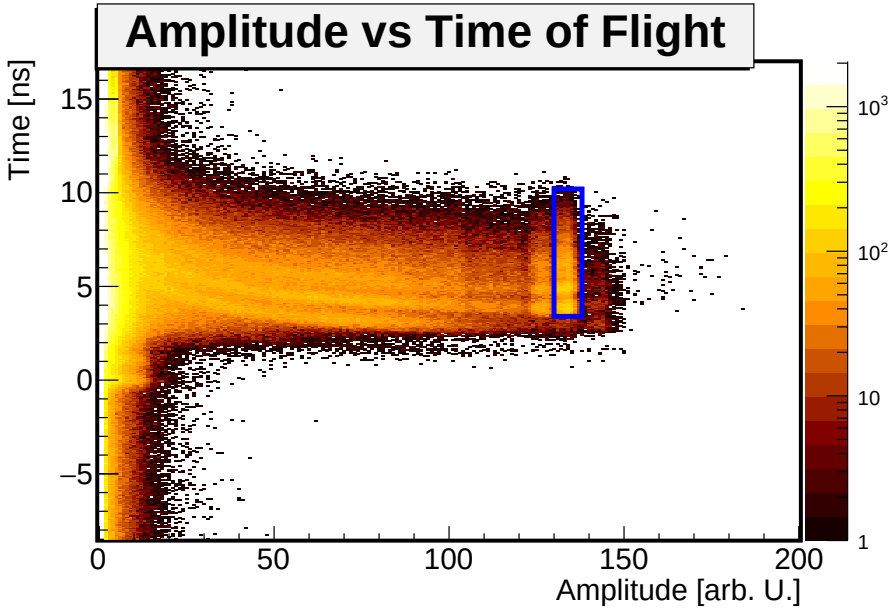
Deuteron CH_2 Scattering

- Recoil and ejectile can be measured in coincidence
- Symmetrical measurements only at a few angles because of fixed detector positions
- Left: Recoil protons measured at 45.9°, deuterons were at 25.9°



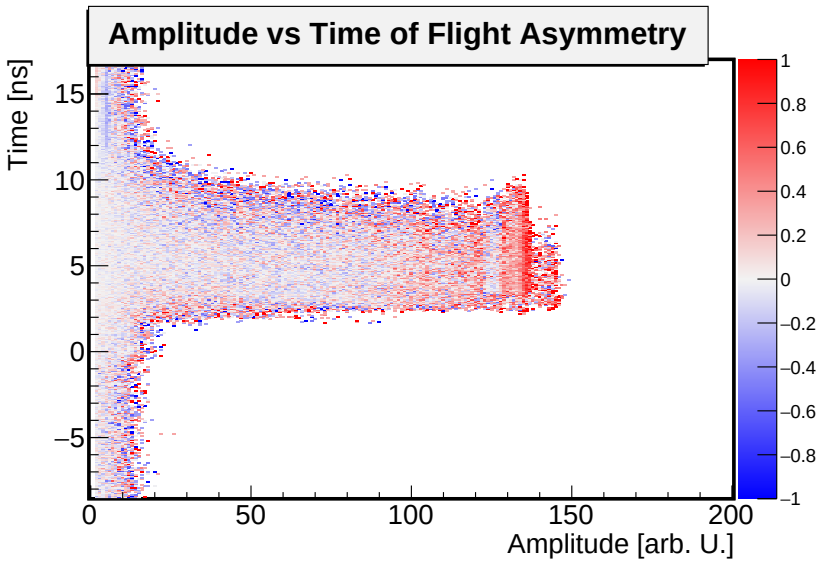
Polarization Measurement

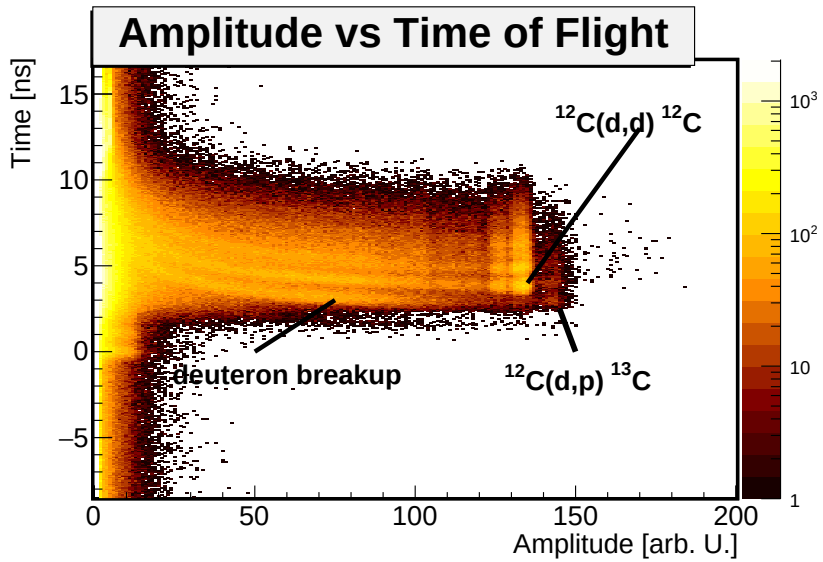




- Asymmetry $\epsilon = \frac{N_L - N_R}{N_L + N_R}$
- Counts in elastic channel, ^{12}C(d,d)^{12}C, $\theta = 40°$

Bin by Bin Asymmetry

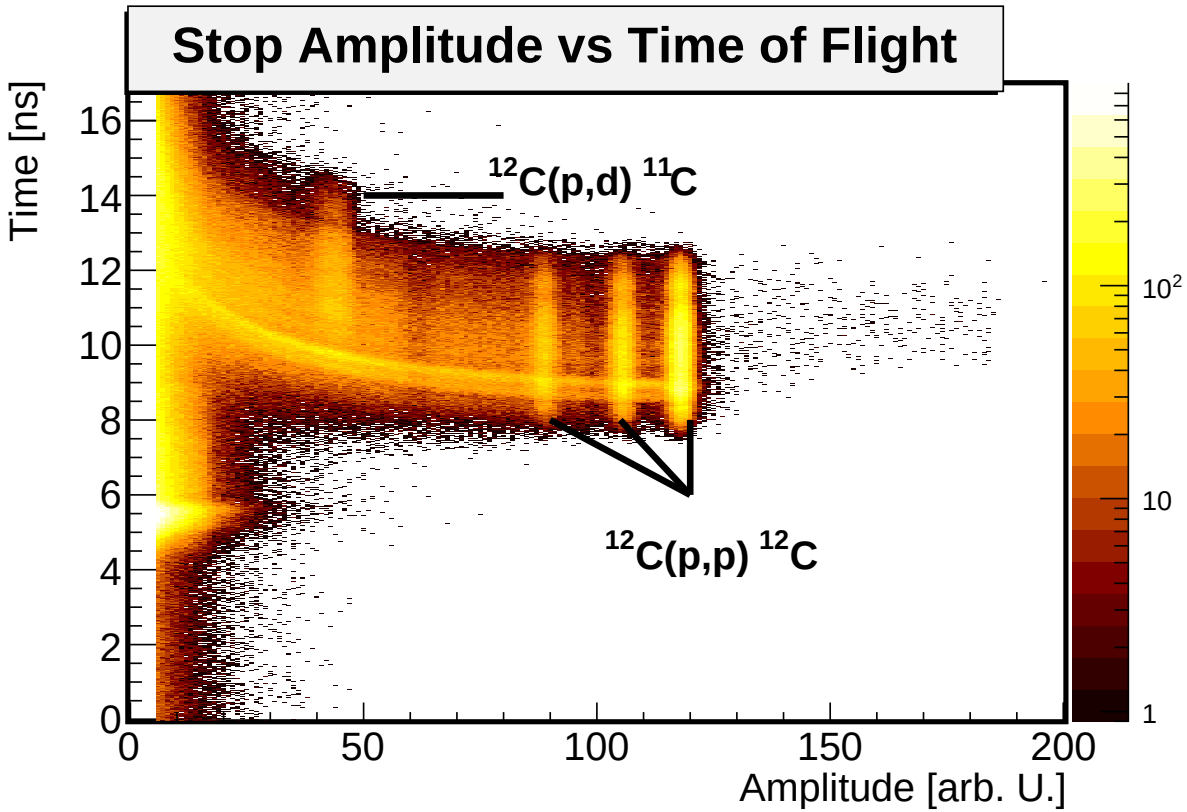




- Asymmetry between positive and negative polarization for each bin

Proton Carbon Scattering

- Protons scattered off CH_2 target, $\theta = 52.5°$



Summary

- New read-out electronics tested successfully
- Implemented time of flight measurement
- Measured polarization, proton and deuteron spectra

Outlook

- Constant polarization measurements in future beam times
- More extensive studies, longer measurements, influence of targets, systematic errors ...
- Aim: Measure deuteron tensor analyzing powers at 75 MeV, remeasure vector analyzing power